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ABSTRACT

Current research suggests that the difference in mathematics achievement between males and females in and beyond the junior high school grades is a direct consequence of the decision by many girls not to take advanced mathematics courses during high school. The first section of this paper indicates at least three factors influence this decision: (1) a lower feeling of competency among many females; (2) acceptance by many females that mathematics is a male activity; and (3) the feeling among many females that mathematics is not likely to be of much use in future career aspirations. Sections II, III, and IV compare the scores of males and females on an objective-referenced mathematics test and on a norm-referenced test. All of the scores reported are for fourth, eighth, and twelfth grades and all reflect the national pattern: that girls compare favorably with or higher than boys in the elementary grades, but show lower achievement levels in the upper grades. Section V offers some recommendations which might serve to alter this pattern of weaker mathematics preparation found among girls. These recommendations are addressed to teachers, counselors, administrators, and parents, and suggest specific ways of encouraging more girls to enroll in mathematics courses. (Author/MP)

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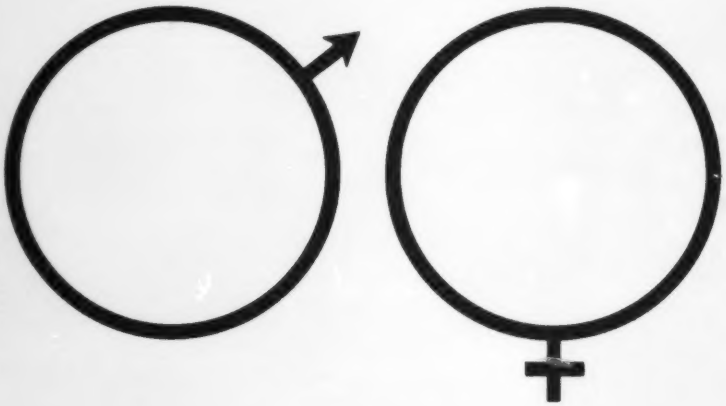

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A COMPARISON OF THE MATHEMATICS ACHIEVEMENT OF MALES AND FEMALES

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A COMPARISON OF THE MATHEMATICS ACHIEVEMENT OF MALES AND FEMALES

Introduction

Previously, numerous studies have reported a significant difference in mathematics achievement between males and females. Generally, males did better than females. This difference, however, has not been found at all ages, but basically among persons in and beyond the junior high school grades.

The generalization that males outperform females in mathematics must be qualified. Until the junior high school years, boys and girls tend to show nearly identical scores in both the computation and application domains of mathematics (application problems often are referred to as "word" or "story" problems, while computation problems involve addition, subtraction, multiplication, and division skills). After junior high school males have done better in botn domains. However, in the basic computation skills the level of performance has been only slightly better. It has been in the ability to apply the computation skills (application problems) and handle advanced mathematical concepts that males have tended to do better.

Explanations for this phenomenon are varied and complex, but current research suggests this difference is a direct consequence of the decision by many girls not to take advanced mathematics courses during high school. As is suggested throughout this paper, a weak background in mathematics represents a serious limitation on an individual's future career options. Section V offers some recommendations which might serve to alter this pattern of weaker mathematics preparation found among girls.[1]

The first section of this paper suggests an explanation why many girls fail to enroll in elective mathematics courses. Section II compares the scores of males and females on the objective-referenced mathematics tests of the 1976 Wisconsin Pupil Assessment Program. Section III looks at three mathematical subdomains (use of whole numbers, decimals, and fractions) on the objective-referenced tests. Section IV reports the results of students on the Comprehensive Tests of Basic Skills, a norm-referenced test.

SECTION I

Review of the Literature on Sex-Related Differences in Mathematics Achievement

Some have suggested that the sex-related difference in mathematics performance is simply a consequence of girls developing a negative attitude toward mathematics at a very young age. This line of reasoning further suggests that the relationship between one's attitude toward mathematics is considerable. For example, one study of elementary school children concludes that a child can hold a negative attitude toward such subjects as spelling, reading, or language and still do well. However, in arithmetic a negative attitude was found to correlate directly with a lower performance level.[2] More recent research by Aiken also reports a low, yet significant, correlation between the attitude one has toward mathematics and the level of success.[3]

Other research, however, contradicts this conclusion. As a case in point, Suydam and Weaver maintain there is no solid body of evidence to document the popular assertion that there is a significant positive connection between pupil attitudes toward mathematics and achievement in the subject.[4] Even if one accepts the research showing a positive linkage between attitude and achievement, this still leaves the "chicken and egg" dilemma. It may be that a low level of achievement in mathematics "causes" a negative view of the subject. In any case, it is difficult to explicate a causal relationship between one's attitude toward mathematics and success or failure in the subject.

Perhaps the most valid explanation for the weaker performance in mathematics by girls after junior high school is that many high school girls avoid elective mathematics courses. Fennema maintains that many studies purporting to compare the mathematics performances of males and females are really comparisons of one group of students who have taken more mathematics (usually males) with another group having a weaker background in mathematics (usually females).[5] Figures collected by the Wisconsin Department of Public Instruction, for example, show that enrollment in courses beyond algebra favors boys by a ratio of about 2:1.[6] In effect, when comparisons are made between females and males with similar mathematical preparation, the score differential disappears totally in some cases and is educationally insignificant in others.[7]

In addition to lowering the overall level of performance in mathematics by females, the decision by many young women to stay away from advanced mathematics has an additonal consequence: fewer females than males

have the necessary background for college mathematics. This is one important reason why mathematics related careers (including engineering and the physical sciences) are dominated by males. One recent study, for example, notes that less than five percent of all doctorates in the physical sciences are held by women.[8]

At this point, the most important question must be why females represent only about one-third of the enrollment in elective mathematics courses in Wisconsin public schools. As suggested above, the theory that this is a function of the development of a negative attitude toward mathematics among females is less than satisfactory for two reasons. First, the evidence is not consistent. Second, this explantion is too limited, for it fails to tell us why the negative orientation develops. Girls at the elementary school age do as well in mathematics as boys, so it is not simply a case of frustration or failure bringing about a negative view of mathematics, with the ultimate consequence being the decision to avoid subsequent electives.

More satisfactory explanations focus on the role of affective variables. One hypothesis suggests that at a very young age girls begin to perceive mathematics as not very useful. For example, research indicates that girls are more inclined to anticipate a career in which there is little or no use of mathematics.[9] More current research by Fennema and Sherman, however, shows only slight differences between males and females in their feelings about the utility of mathematics.[10] The authors suggest that their finding may reflect a growing similarity between males and females regarding the usefulness of mathematics.

Additional research indicates that girls do not feel as competent in mathematics as boys.[11] Although the reason this attitude develops is not clear, it begins at a relatively young age. Fennema and Sherman report that in their study of students (sixth through twelfth grade) boys showed a higher confidence level in mathematics at each grade level.[12] It is significant to note that the correlation ($r=.40$) between confidence in doing mathematics and achievement in mathematics was higher than for any other affective variable investigated in their study.

Perhaps, as suggested by several authors, one of the most significant reasons why many young women take only the required mathematics in high school is that they perceive mathematics as a masculine activity. Fennema comments on this possibility.[13]

> Mathematics in adult life is seen to be more closely related to the male sex role than to the female sex role. This belief on the part of boys as well as girls probably accounts for the increasingly better performance of boys in mahtematics.

It is interesting to note that males are more likely to accept this stereotype than females.[14]

The discussion to this point would indicate that at least three factors influence the decision by many young women to avoid advanced mathematics courses: a lower feeling of competency among many females, acceptance by many females that mathematics is a male activity, and the feeling among many females that mathematics is not likely to be of much use in future career aspirations.

The origins of these orientations are difficult to identify. However, one important source appears to be the parents. Reseach indicates that parents are less likely to encourage their daughters to pursue a career in mathematics or science.[15] Others point to the absence of appropriate female-role models as being a significant factor in explaining this behavior pattern (most mathematics teachers, for example, are men).[16] Additional authors suggest that male mathematics teachers hold negative biases toward females and that they offer less encouragement.[17] Others emphasize the sexism in mathematics textbooks: males typically are portrayed working in occupations where mathematics is used, while females usually are shown in the role of homemaker.[18]

In summary, the research literature on sex-related differences in mathematics achievement again and again points to the influence of affective variables. In particular, it is the decision by many young women to stay away from advanced mathematics that accounts for the lower achievement levels in mathematics by females. It is important to note that this paper has not discussed hypothesized differences in cognitive abilities (for example, verbal skills, spatial visualization, or general intelligence) between males and females. Research does not support any hypotheses that females are less able to deal with mathematics because of some limited cognitive capability.[19]

SECTION II

Comparative Scores of Boys and Girls on the Objective-Referenced Mathematics Test

Introduction

In the spring of 1976 randomly sampled public school students throughout the state participated in the Wisconsin Pupil Assessment Program. Information about the mathematics backgrounds of students was not solicited, so that the comparisons between males and females do *not* control for the number of mathematics courses taken. This is an important consideration and should be kept in mind throughout the discussion of results.

The two Program goals were to determine how well students perform in mathematics and to determine how they compare with national samples of students of the same ages. To ascertain how well students can solve basic mathematics problems, Wisconsin educators from elementary through university levels identified basic objectives students would be expected to meet at the fourth, eighth, and twelfth grades. Each version of the test is based on many of those objectives and consists of several unique forms. Each student took only one form of the test.

The fourth grade students were tested in six mathematics domains, packaged into two test forms. Eighth and twelfth grade students were tested in eight domains, packaged into three test forms. Each test form was taken by about 1,700 students. Approximately 90 percent of the items on the eighth and twelfth grade tests were identical. The test forms at each grade level are shown in Table 1.

Table 1
Domains on the Objective-Referenced Tests*

Fourth Grade	Eighth and Twelfth Grades
Computation	*Computation*
Addition	Addition
Subtraction	Subtraction
Multiplication	Multiplication
Division	Division
Applications	*Applications*
Money Application	Money Application
Measurement	Measurement
	Ratio and Proportion
	Percent

*Ratio, Proportion, and Percent are included within the Applications category, though many items could fit under the heading, Computation.

To determine national comparison, the Comprehensive Tests of Basic Skills was administered to approximately 5,100 students, with about equal numbers at each grade level. This test, produced by CTB McGraw-Hill, is a commercial instrument designed to compare individuals or groups with a national average.

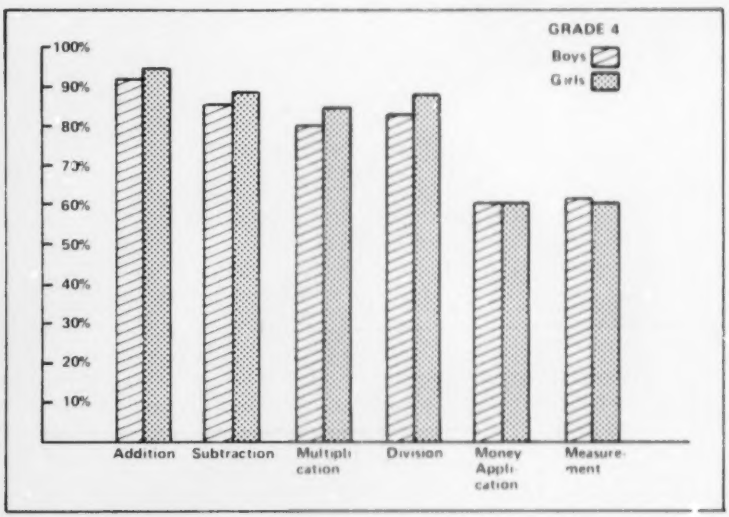
Test Scores at the Fourth, Eighth, and Twelfth Grades for Males and Females on the Objective-Referenced Tests

Generally, the scores of Wisconsin male and female students on the objective-referenced mathematics tests reflect the national pattern. That is, girls compare favorably with boys in the elementary grades, but show lower achievement levels in the upper grades.

Fourth Grade

At the fourth grade level students were tested in six domains. In the four computation domains the girls average about 3-4 percent better than the boys. However, in the two applications domains, money application and measurement, the scores are nearly the same. Both groups average about 60 percent correct.

Figure 1
Scores of Fourth Grade Boys and Girls in Mathematics



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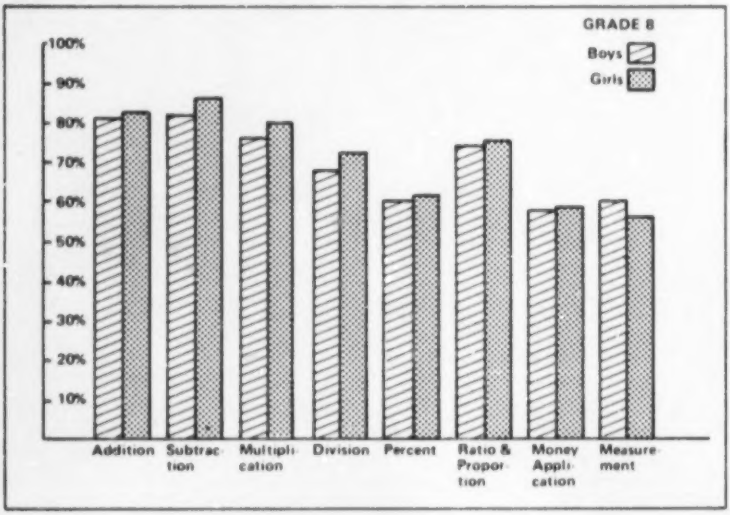
Eighth Grade

At the eighth grade level the girls perform better in seven of the eight domains. The greatest difference in performance occurs primarily in the four computation domains, while the differences in application are smaller. For example, the boys answer a higher percentage of the items in measurement correctly.

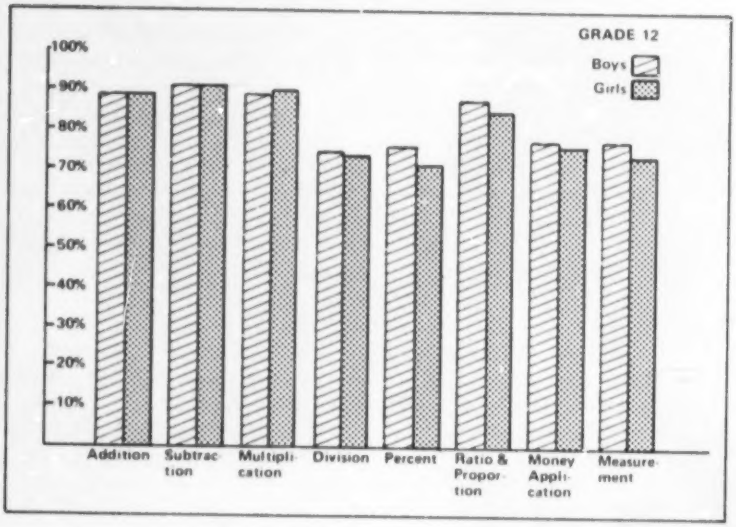
Figure 2
Scores of Eighth Grade Boys and Girls in Mathematics



Twelfth Grade

The twelfth grade sample shows that the differences between boys and girls in the computation domains are insignificant. This pattern probably reflects the fact that girls do as well or better than boys in the early years of mathematics, where basic computation skills are emphasized. The higher scores by the boys in application at this age level would appear to be a consequence of the fact that twelfth grade boys are more likely to have been enrolled in advanced mathematics courses.

Figure 3
Scores of Twelfth Grade Boys and Girls in Mathematics



SECTION III

Comparison of Boys and Girls in the Use of Whole Numbers, Decimals, and Fractions

Within the four computation domains (addition, subtraction, multiplication, and division) on the eighth and twelfth grade objective-referenced tests, there are problems which require the use of whole numbers, decimals, or fractions. A comparison of boys and girls in these subdomains shows an interesting pattern.

At the eighth grade level the girls score higher in each subdomain. The greatest differences occur in the use of fractions and decimals, where girls average about five percent higher. In whole number usage the girls average about two percentage points above the boys.

For the twelfth grade sample the girls continue to do better than the boys in whole numbers and decimals, but the differences are smaller than among eighth graders. In fractions the boys score two percentage points above the girls. Although the differences in results are small, there appears to be a trend, in that the boys catch up with the girls between the eighth and twelfth years of school in terms of the ability to do computation. This is likely to be a function of boys taking more mathematics courses during this four year period.

Table 2
Comparison of Boys and Girls in the Use of Whole Numbers, Decimals, and Fractions

	Percent Correct-Eighth Grade		Percent Correct-Twelfth Grade	
	Boys	Girls	Boys	Girls
Whole Numbers	87%	89%	88%	89%
Decimals	73%	78%	85%	87%
Fractions	74%	79%	81%	79%

SECTION IV

Comparison of Boys and Girls on the Mathematics Test of the Comprehensive Tests of Basic Skills

In addition to testing Wisconsin students on an objective-referenced test in mathematics, samples of students from the fourth, eighth, and twelfth grades were tested on the mathematics portion of the Comprehensive Tests of Basic Skills. This is a norm-referenced test showing how Wisconsin students compare with students of a similar age throughout the country. Percentile scores range from 1 to 99. A percentile score of 75, for example, means that 75 percent of the national norm group scored lower on this test than the average Wisconsin student. It does not mean that the student answered 75 percent of the test questions correctly, as a score of 75 would mean on the objective-referenced tests.

The results show an interesting pattern. Girls do much better at the fourth grade, while in the eighth grade the differences are minimal. However, by twelfth grade girls score five percentile points below the boys. Probably the most important reason for this difference is that the CTBS mathematics test inlcudes questions measuring knowledge of advanced mathematics. Since fewer girls are likely to have taken advanced mathematics in high school, a lower percentile score would be expected.

Table 3

National Percentile Scores of Wisconsin Students on the Mathematics Test of the Comprehensive Tests of Basic Skills: Boys Compared With Girls at the Fourth, Eighth, and Twelfth Grade Levels

	Fourth Grade		Eighth Grade		Twelfth Grade	
	Boys	Girls	Boys	Girls	Boys	Girls
Percentile Scores	64	71	74	75	54	49

SECTION V

Recommendations

There is no substantive evidence to show that girls are less capable in mathematics than boys. The basic reason they show lower achievement scores is that there is a failure of many girls to enroll in mathematics courses which are not required. For example, in Wisconsin high schools during the 1975-76 school year, girls comprised 50 percent of the enrollment in elementary algebra courses (first year mathematics), but only 37 percent of the enrollment in fourth year mathematics courses.

There is a compelling reason for encouraging more girls to enroll in mathematics courses. As the traditional distinctions between "men's" and "women's work" disappear, more and more often men and women compete for the same jobs. As our society becomes increasingly technical, persons with a weak background in mathematics have fewer options because more occupations are closed to them.

Teachers of elementary mathematics (k-6) should be as concerned about their students' attitudes toward mathematics as they are about achievement. Elementary school teachers should also make their students aware of the role of mathematics in careers, even if this is done only in a very general way. They should also work in a positive way to counter sex role stereotypes which develop in young children and which identify mathematics and mathematics related topics as primarily male domains. Secondary school teachers of mathematics frequently will have to work with students who already have formed negative feelings about mathematics. These attitudes may be (1) that mathematics is not important, (2) that mathematics is unpleasant, and (3) that mathematics is more appropriate for boys. Secondary school mathematics teachers should identify students having one or more of these attitudes and work to create a more positive orientation toward mathematics on the part of the student. Teachers also should be aware that they may cause their students to develop a negative orientation toward mathematics. It also is important that they stress the role of mathematics as a "critical filter," in the sense that s lack of mathematical preparation will eliminate many college and career choices.[20]

Many secondary school mathematics programs commonly are designed to prepare students for calculus courses in college. Many high school students identified as not capable of studying calculus are discouraged from continuing their study of mathematics. High school mathematics departments need to recognize their responsibility to develop programs which provide increased opportunities for mathematics study for all students. They also should encourage students to enroll in these

programs once they become available. Traditional remedial programs have not met this need. Other departments also should recognize their responsibility to provide experiences in mathematics by showing the application of mathematics to their particular discipline. Mathematics teachers also should illustrate the application of their subject matter to other areas of study.

School guidance and counseling personnel should become more aware of the secondary mathematics required for various undergraduate majors, for courses in vocational and technical schools, and for entrance into various career fields. It is well known that many colleges and universities require two years (algebra and geometry) of high school mathematics for admission. (The University of Wisconsin-Madison, for example, requires the equivalent of three years of high school mathematics to graduate). What is less well known is that students having only this level of preparation cannot successfully compete in many undergraduate majors. Counselors should encourage students to be certain they have not only the minimal requirements for admission, but such additional mathematics as will enable them to maximize their options in the future.

School administrators should take whatever action is necessary to provide equal educational opportunities for both sexes and to actively oppose sex role stereotyping which develops within the school and in the larger society.

Parents have one of the most important roles to play. They should not promote sexist attitudes toward mathematics in their children. Schools may have to develop programs to inform parents of the need for increased mathematical training for all students. In combination, the school and parents may successfully combat the development of negative mathematics orientations found in many children, orientations which only serve to limit the child's opportunities as an adult.

Footnotes

[1]Section V was written by Chambers, Sections I-IV by Allen. A special thanks is given to Elizabeth Fennema of the University of Wisconsin-Madison Department of Education for her substantive and editorial comments.

[2]E. E. Brown and T. L. Abel, "Research in the Teaching of Elementary School Mathematics," *Arithmetic Teacher*, 12 (1965), pp. 547-549. For additional research on the attitudes of young children toward mathematics, see V. M. Stright, "A Study of Attitudes Toward Arithmetic of Students and Teachers in the Third, Fourth, and Sixth Grades," *Arithmetic Teacher*, 7 (1960), pp. 280-286; and W. L. Herman, "How Intermediate Children Rank the Subjects," *Journal of Educational Research*, 56 (1963), pp. 435-436.

[3]L. R. Aiken, "Update on Attitudes and Other Affective Variables in Learning Mathematics," *Review of Educational Research*, 46 (1976), pp. 293-311.

[4]M. N. Suydam and J. F. Weaver, *Using Research: A Key to Elementary School Mathematics* (Columbus, Ohio: ERIC Information Analysis Center for Science, Mathematics and Environmental Education, Ohio State University, 1975).

[5]Elizabeth Fennema, "Influences of Selected Cognitive, Affective, and Educational Variables on Sex-Related Differences in Mathematics Learning and Studying," National Institute of Education paper, Grant Number P-76-0274 (Madison, Wisconsin: University of Wisconsin-Madison, October 1976).

[6]See *Districts by Curriculum Offerings*, 1975-76. Records kept at the Wisconsin Department of Instruction Information Dissemination Center, 126 Langdon St., Madison, Wis.

[7]Fennema, op. cit.

[8]John A. Centra, *Women, Men, and the Doctorate* (Princeton: Educational Testing Service, 1974).

[9]See E. W. Haven, "Curriculum Innovations and Practices in the American High School," *School and Society*, 98 (April 1970), pp. 239-241; Lynn H. Fox, "Women and the Career Relevance of Mathematics and Science," *School Science and Mathematics*, 76 (April 1976), pp. 347-353; and Lynn H. Fox and S. A. Denham, "Values and Career Interests of Mathematically and Scientifically Precocious Youth," in J. C. Stanley, D. P. Keating, and Lynn H. Fox, *Mathematical Talent: Discovery, Description, and Development* (Baltimore: John Hopkins University Press, 1974).

[10]Elizabeth Fennema and Julia Sherman, "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors," *American Educational Research Journal*, 14 (Winter, 1977), pp. 51-71.

[11]See V. J. Crandall, W. Katkovsky, and A. Preston, "Motivational and Ability Determinants of Young Children's Intellectual Achievement Behaviors," *Child Development*, 36 (1965), pp. 91-109; J. Ernest, *Mathematics and Sex* (Santa Barbara: Mathematics Department, 1975); E. J. Sweeney, *Sex Differences in Problem Solving*, unpublished doctoral dissertation, Stanford University; and G. A. Cleveland and D. L. Bosworth, "Study of Certain Psychological and Sociological Characteristics as Related to Arithmetic Achievement," *Arithmetic Teacher*, 14 (May, 1967), pp. 383-387.

[12]Fennema and Sherman, op. cit.

[13]Elizabeth Fennema, "Sex Differences in Mathematics-Learning: Why???" *The Elementary School Journal*, 75 (December, 1974), p. 187. Also see C. F. Elton and H. A. Rose, "Traditional Sex Attitudes and Discrepant Ability Measures in College Women," *Journal of Counseling Psychology*, 14 (1967), pp. 538-543.

[14]See Fennema (1976), op. cit.

[15]H. S. Astin, *The Woman Doctorate in America* (New York: Russell Sage Foundation, 1969). The reader's attention also is directed to T. Poffenberger and D. A. Norton, "Factors in the Formation of Attitudes Toward Mathematics," *Journal of Educational Research*, 52 (1959), pp. 171-176.

[16]See Fennema (1974), op. cit, and Roy D. Goldman and Barbara Newlin Hewlitt, "The Scholastic Aptitude Test 'Explains' Why College Men Major in Science More Often Than College Women," *Journal of Counseling Psychology*, 23 (1976), pp. 50-54.

[17]Joan Beck, "Sexist Math: Why Women Don't Count in the Classroom," *Equal Rights Monitor*, 3 (March/April, 1977), p. 12.

[18]Fennema (1974), op. cit.

[19]For a summary of research on the relationship between cognitive ability and mathematics achievement, see Fennema (1976), op. cit.

[20]See Lucy W. Sells, "High School Mathematics as the Critical Filter in the Job Market," in *Developing Opportunities for Minorities in Graduate Education*, Proceedings of the Conference on Minority Graduate Education, (Berkeley: the University of California, May 1973).

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